Finding the Perfect Fit: An Overview of Blower Technologies

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LaCrosse WI WWTP

- Four New Turbo Blowers
- New Diffusers with Tapered Layout
- DO Control System
- Automated Air Valves
CASE STUDY

LaCrosse WI WWTP

<table>
<thead>
<tr>
<th>Year</th>
<th>Total KWH</th>
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<tbody>
<tr>
<td>2006</td>
<td>4,753,219</td>
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<tr>
<td>2007</td>
<td>5,677,565</td>
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<td>2008</td>
<td>6,271,078</td>
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<td>2009</td>
<td>6,206,803</td>
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<td>2010</td>
<td>6,229,169</td>
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<td>2011</td>
<td>6,118,722</td>
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<tr>
<td>2012</td>
<td>4,706,782</td>
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<td>2013</td>
<td>4,464,431</td>
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28.81% - decline from 2008

$99,366 <-- annual savings based on $0.055 /kWh
Sterno, Sweden Case Study

Breakdown of Savings

• 50% High Efficiency Blowers
• 38% New Diffusers
• 12% D.O. Control System
LaCrosse WI Case Study

Breakdown of Annual Savings

• $50,000 High Efficiency Blowers
• $38,000 New Diffusers
• $12,000 D.O. Control System
BLOWERS
Presentation Outline

1) Comparison of Positive Displacement vs Centrifugal

2) Summary and Explanation of Different Blower Technologies
   A) Positive Displacement
   B) Centrifugal (Includes High Speed Turbo – New)

3) Evaluation Process
   A) Application Compatibility
   B) Energy Cost
Blower Technologies

Positive Displacement vs Centrifugal

- Positive Displacement entraps a volume of gas and reduces it
- Centrifugals are dynamic and use velocity to overcome pressure
Positive Displacement vs Centrifugal

- **Centrifugal**
  - variable flow vs constant pressure

- **Positive Displacement**
  - variable pressure vs constant flow
Positive Displacement vs Centrifugal

**Centrifugal**
1) Multistage
2) High Speed Turbos
3) Single-Stage
   - Integrally Geared

**Positive Displacement**
1) Twin Lobe
2) Tri Lobe
3) Screw
Varied Applications for Wastewater

- Constant Pressure
- Constant Flow
Centrifugal vs. Positive Displacement

- Varying Speed of a PD blower
- As speed decreases so does flow and ability to produce pressure
- Constant back pressure is maintained
- Flow is reduced
• Varying Speed of a PD blower
• As speed decreases so does flow and ability to produce pressure
• Constant flow is maintained with variable pressure
• Varying the speed of centrifugal blower
• As speed decreases the curve shifts down left
• Constant back pressure is maintained
• Flow is reduced
Centrifugal vs. Positive Displacement

- Varying the speed of centrifugal blower
- As speed decreases the curve shifts down left
- Constant flow is maintained with variable pressure
History of Positive Displacement Blowers

- Mid 1800’s Cornsville, IN
- Root’s Brothers trying to improve the water wheel
- 1st Design was made out of wood
- Discovered the new invention could move a quantity of air
- “The Roots” Blower
Common Types in Wastewater

- Rotary Lobe (AKA Roots Blower)
  - Twin Lobe
  - Tri Lobe

- Screw Blower
Positive Displacement Advantages

• Best for **low flow, high pressure applications**
• Low horsepower offering
• Can withstand Frequent Starts/ Stops
• Up to 80% Turndown
• Economical
• Flexibility with Blower Package
• Common Product
Positive Displacement Disadvantages

• Several regular maintenance items
• Problems at higher capacities
  – Valve & seal leakage
  – Mechanical friction
  – Flow discontinuities increase rapidly and lower efficiency
• Pulsation
• Loud
• Limited high horsepower offering
**Lobe**

- Twin lobe (or tri) impellers rotate transports the air around the periphery of the housing
- External Compression causes vibration and pulsations
- Belt Driven
Blower Technologies: **Positive Displacement**

**Screw**

- Internal Compression
- The Rotation causes less vibration and pulsations
- Gear or Belt Driven *(Depending on the manufacturer)*

http://www.comer-srl.net/product.html
Blower Technologies: **Positive Displacement**

**Screw**

1. Air enters the compression chamber
2. Air is moved to the discharge as the rotors turn
3. The air is compressed as it is transferred
4. Air is pushed out into the pipeline

http://www.comer-srl.net/product.html
Blower Technologies: Positive Displacement

Lobe VS Screw

Savings

- Savings
- Oil Pump, Cooling Fan, Ventilation Fan
- Motor
- Frequency Converter
- Transmission (drive gear vs belt)
- Pressure Drops
- Compression

Total Power Consumption (KW)

Lobe Blower

Screw Blower

Innovation    Service    Experience
mulcahyshaw.com
Performance Comparison

**Screw Blower**
- Input power: 55 kW
- Inlet filter design = energy savings
- Internal compression = energy savings
- Smooth silencer = energy savings
- Integrated gearbox = energy savings

**Lobe Blower**
- Input power: 75 kW
- Pulley = losses
- External compression = losses

**Vs.**

thermodynamic energy consumption

Energy savings
Common Types in Wastewater

- Multistage Centrifugal
  - commonly incorrectly referred to plainly as “centrifugal”

- High Speed Turbo
  - Magnetic Bearing
  - Air Bearing

- Integrally Geared Single Stage
Blower Technologies: Centrifugal
Centrifugal Advantages

- Wide operating range
- Low maintenance
- High horsepower capabilities
- High efficiency potential
  - Varies based on size
- High speed capability
- Reasonable output sound range
Centrifugal Disadvantages

• Can be less efficient and unstable at low flows
• Limitations on starts/stops
• Complicated control systems
• High overhead costs
Blower Technologies: **Centrifugal**

**Multistage**

• Air is forced through the impeller
• Velocity of air is converted to pressure (mostly in the diffuser)
• Increase is staging allows for an increase in pressure
• Used for Air and Gas applications
Blower Technologies: Centrifugal

Single-Stage Integrally Geared

• First utilized in natural gas compression
• They operate at high impeller speeds and can operate at pressure ratio's in excess of 4:1
• Light weight and compact
High Speed Turbo

• Two Kinds:
  1) Magnetic Bearing
  2) Air Bearing

• Impeller forces air to rim of impeller, increasing the velocity

• Newest Technology
High Speed Turbo

Magnetic Bearing

- Rotor is magnetically levitated and makes no contact with housing

- Operating principle:
  - Position sensor detects displacement
  - Electromagnets get activated, shaft is attracted to the opposite direction
Blower Technologies: Centrifugal

Air Bearing
HSI Frame 5 – Wheel 4 Performance Map (Dual Compressors)

$P_{ref} = 14.700$ [psi], $T_{ref} = 527.070$ [°R], $\gamma_{ref} = 1.401986$, $Z_{ref} = 53.3454$ [ft-lbf/ftm-R]
Evaluation

Main Aspects

1) Application Compatibility
2) Energy/ Life Cycle Cost
Application Compatibility

1) Site Conditions
2) Frequency of Starts/Stops
3) Frequency of use
4) Pressure Levels (constant or variable)
5) Turndown
6) Noise Level
Pressure

- Constant Pressure – Aeration Tank
- Variable Pressure – Digesters, SBRs
Frequency of Starts/ Stops

- Continual Operation – Aeration Tank
- Frequent Starts/ Stops – Digesters, SBRs
Turndown

- Wide Range of Operation
- Multiple Blowers
Efficiency

- Focus on the power of the complete blower package, commonly known as "Wire to Air"
- Standard: ASME PTC-13 (under development)
Evaluation

• Efficiency vs. Capital Costs
• Focus on the power required to deliver a specified flow and pressure at the discharge of my blower system
• Wire to Air Power